CURRENT SPEECH-, OLFACTORY- AND PULMONARY REHABILITATION AFTER LARYNGECTOMY

Ph.D. Thesis

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I. Introduction

The larynx plays an important role both in voice production and in the protection of the airways. Since the first laryngectomy performed by Billroth in 1873, total laryngectomy has been a vital step in the treatment of cancers of the larynx and hypopharynx. After laryngectomy however, essential functions such as breathing, voice production, swallowing, olfaction and airway protection undergo changes or are impaired.

One of the most obvious consequences of the surgery is that the patient looses the organ of voice production and is therefore unable to utter sounds the natural way that is with the vibration of vocal cords. Currently the implantation of voice prosthesis seems to be the main trend in speech rehabilitation. As regards voice quality it is the voice prosthesis that produces the most natural-sounding speech and it is also relatively easy to learn. The prosthesis is placed into an artificially created fistula 5-8 mms below the upper edge of the stoma in the neighbouring walls of the trachea and the oesophagus. The insertion of the prosthesis allows air from the lungs to pass through, enter the pharynx and by vibrating the pharyngo-oesophageal segment (PES) or so-called neoglottis and produce sound.

Following laryngectomy, the upper airways are excluded from normal ventilation. Consequently, air-exchange happens through the tracheostoma resulting in a significantly impaired olfaction, sometimes even anosmia. The methods previously used to be applied to repair the olfaction of laryngectomized patients (eg. larynx-bypass devices) has not spread widely. The break-trough was the ”polite yawning” maneuver (Nasal Airflow Inducing Maneuver /NAIM/), which has become popular world-wide.

Normally, the protection of the lower airways is secured by the upper airways by preventing aspiration and maintaining a microclimate. As a result, inspired air warms up, becomes humid and airway resistance necessary for mucociliary transport and mucociliary transport itself becomes more effective. Air that enters through nasal breathing is 22 ˚C warm and its relative humidity is 40%, however, passing through the upper airways it becomes 37˚C warm and its relative humidity is 99% at the level of the trachea providing ideal circumstances for mucociliary transport.

Air inspired through the stoma is 22 ˚C warm and its relative humidity is 40%, when reaching the trachea it is only 28 ˚C warm and its relative humidity is 50% thereby, mucociliary transport is less effective there is an increased crusting of the mucosa and an increased salivation. As a result, coughing fits become more frequent and an increased crusting and tracheal discharge can be observed. Patients have to clean the stoma and remove crusts nearly every day. The above changes result in reduced life-quality and also play a considerable role in problems with communication. As a solution an easily applicable device has been invented which has become known as the Heat and Moisture Exchanger (HME) worldwide.

During the period of May 1996 - October 2011 424 total laryngectomies were performed at our clinic due to malignant tumours of the larynx and/or hypopharynx. This meant an average 28 laryngectomies annually. Therefore, postoperative rehabilitation concerns a significant patient population.

II. Aims of the study

Unfortunately, complete rehabilitation following total laryngectomy is still in its early stages in Hungary. In my work I intended to perform examinations on a Hungarian patient population focusing on three possible areas of rehabilitation (voice production, olfaction, pulmonary rehabilitation) the results of which were expected to prove an improved life-quality and thus convince specialist circles in the country about the importance and necessity of the introduction and promotion of up-to-date rehabilitation techniques.

Summary of main targets in points:

1. Analysis of 15 years of experience gained with the application of the voice prosthesis focusing on those cases when due to a narrowing of the hypopharyngeal-oesophageal junction the insertion of the prosthesis would have been so difficult that prior to surgery a dilatation of the narrowing had to be carried out.

2. Assessment and justification of the effectiveness of the voice prosthesis the leading method of voice rehabilitation.

3. Examination of the effectiveness of the 'polite yawning' maneuver in speech rehabilitation with subjective and objective methods and its introduction into the everyday routine.

4. Providing proofs for the effectiveness of the application of the HME with a questionnaire-survey and pulmonary function tests thereby also justifying the importance of the method to be made available for patients in Hungary via creating ways of financing.

Relating to the 3 main areas of the present study (speech-rehabilitation with voice prosthesis, olfactory and pulmonary rehabilitation) materials and methods and results are discussed separately in the following.

III. Speech-rehabilitation

III.1 Our experiences with the voice prostheses

III.1.1 Materials and Methods

Between May 1996 and 31. October 2011 424 total laryngectomies and 244 voice-prosthesis implantations were performed at our Department. Voice prosthesis implantations were performed in one-sixth, i.e. 66 patients. Out of our patients 59 patients were male and 7 were women. The voice prosthesis was inserted via primary puncture together with the removal of the larynx in 2 cases, after laryngectomy that is via secondary puncture in 64 cases and as replacement in 178 patients. All interventions were performed under intratracheal anaesthesia except for one where local anaesthesia was used. Until September 2004 Provox voice prostheses were used in 90% of the cases and VoiceMaster in the remaining 10%. From

the end of 2004 only VoiceMaster type voice prosthesis were used. We performed stomaplasty in 7 patients due to a narrow stoma. Four patients received 10 mm, another 4 patients 6 mm and the rest of the patients 8 mm long voice prosthesises. Two patients were known to have pulmonary metastases on implantation. The voice prostheses were implanted into a jejunum segment used for replacement of the oesophagus in 2 patients. In 4 patients the first attempt was unsuccessful due to stenosis of the hypopharyngeal-oesophageal junction. Three patients out of these 4 had undergone full-dose radiation therapy. One of them had previous reconstruction with a jejunum segment due to cancer of the oesophageal orifice. Stricture was benign in all cases, they arose due to postoperative scar-formation. After our failed attempts all 4 patients underwent endoscopic dilatation with balloon catheter under local anaesthesia at the department of internal medicine. During the procedure the 5-8mm stenoses were dilated to 14-16 mm in diameter in 3-5 steps. The required further dilatations with rigid instruments were carried out at our Department under general anaesthesia together with the implantation of the voice prosthesis.

III.1.2 Results

Evaluating implantations performed until the end of October 2011 we can say, that the average time of wear was 9.7 months, period of wear varied between 10 days and 62 months.

The majority of the 178 replacements i.e. 119 cases were due to leaking (67%). In 78 cases it was through the prosthesis (44%), in 27 cases around the prosthesis (15%), and in 14 patients (8%) it was combined. Increased air-resistance due to functional deterioration of the prosthesis necessitated the change in 52 cases (29%). In 7 cases (4%) other causes were in the background.

Granulation tissue was treated with laser or radiofrequency in 12 cases on replacement (7%)

Temporary removal of the voice prosthesis was carried out in 13 patients due to granulation or dilated opening of fistulas.

Permanent removal was carried out in 8 patients upon their request as they could not get used to or were unable to use the implant. Obviously, these patients we consider unsuccessful: they make up 12% of voice prosthesis receivers.

Two of our patients wearing voice prosthesis received radiation therapy. In one of the patients it was due to tumour recurrence occurring in the area of the radical cervical dissection one year after implantation, in the other patient irradiation was indicated by stomal recurrence one year after implantation. Irradiation had no harmful effect on voice prosthesis function during radiotherapy.

Implantation and replacement of the voice prosthesis was more complicated by scar formation, granulation, increased cervical spondylosis, narrow stoma or stenosis of the hypopharynx or oesophagus.

In one patient the prosthesis partially slipped out and when trying to fix it in an out-patient set-up it slipped into the trachea. The prosthesis stuck onto the carina was quickly removed by tracheoscopy.

Insertions into the jejunum segment did not mean any technical difficulty and the prostheses functioned perfectly. Complication arose with one patient who had undergone previous dilatation one week after insertion as detailed in the following.

Previous dilatation was required in 4 patients due to stenosis of the hypopharyngeal-oesophageal junction. In 2 patients of the 4 fibero-endoscopic ballon-catheter dilatation sufficed, dilatation of the lumen with a rigid instrument was only necessary during the initial voice prosthesis implantation, during further replacements the diameter of the hypopharyngeal-oesophageal junction proved to be enough. In one patient, due to recurrent

high-grade stenosis, besides repeated fibero-endoscopic dilatations further interventions were necessary with rigid instrument. As dilatations did not seem to have improved the situation, the stenosis was resolved by free jejunum flap implantation following an unsuccessful pectoralis major myocutaneous flap implantation. One patient received an implant into a jejunum graft following balloon dilatation. Although the prosthesis functioned well during the week after surgery, the patient coughed it out after a week. This referred to a fast dilatation of the fistula which could be explained by the circulatory disturbance in the implanted jejunum flap. Re-implantation was delayed thereafter, the fistule closed spontaneously in 17 days. The patient died 3 months later due to mediastinitis caused by recurrence of the tumour.

III.2 Analysis of the effectiveness of the voice prosthesis from the patients' perspective

III.2.1 Materials and Methods

During the 5-year period between 01.01.2004 – 31.12.2008 we used an internationally accepted questionnaire for the analysis of our experiences with the use of the voice prosthesis as a method of voice rehabilitation in 31 patients who underwent laryngectomy.

Out of the posted questionnaires 22 were answered (71% response rate). The 23 questions can be divided into 4 groups focusing on 1) the voice prosthesis, 2) the created 'new' voice, 3) controversies with the use of the prosthesis and 4) questions relating to changes in quality of life. Of the 23 questions 12 required an answer on a visual analogue scale from 1 to 10.

III.2.2 Results

Before the insertion of the voice prosthesis performed with secondary puncture 1 patient communicated with oesophageal speech, 8 patients with electrolarynx, 7 with pseudobuccal speech and 6 in writing. Both oesophageal speech and electrolarynx assured intelligibility in contrast to pseudobuccal speech. 11 patients (50%) evaluated their own "new" voice for 5 points, 6 patients (27%) for 7 points, 3 patients (14%) for 9 points and 2 patients (9%) for 10 points on a 0-10 scale (where 0 meant extremely poor voice and 10 meant excellent voice). 15 patients (50%) were able to make themselves understood always in quiet environment, 7 patients (32%) were moderately understood. In noisy environment only half of the patients made themselves understood with speech in all circumstances, 6 patients (27%) moderate and 5 patients (23%) rarely. In a noisy environment 8 patients (36%) thought of their voice to be always loud enough, 7 patients (32%) in most of the times and 7 patients (32%) only sometimes. On the phone 14 patients (64%) was always understood , 8 patients (36%) moderately understandable, but only 7 patients (32%) were totally satisfied with their loudness level. In the vast majority of patients the prostheses needed to be changed every 4-5 months. As a reason of the changes 8 patients (36%) reported leakage through the prosthesis, 12 (54%) around the prosthesis, and 2 patients (9%) complained of forced voice formation. During a 24-hour-period 10 patients (45%) reported 4-5 minutes spent on cleaning the prosthesis, 6 patients (27%) 10 minutes, 4 patients (18%) 30 minutes and 2 patients (9%) 1-2 hours. Speech rehabilitation with voice prosthesis improved quality of life significantly in 16 patients (73%) and to a lesser extent in 6 patients (27%). The voice prosthesis greatly facilitated a return to everyday life in all of our patients, 19 of our patients (86%) gave 10 points on the scale 0-10.

IV. Olfactory Rehabilitation

IV.1. Materials and Methods

During the period between September 2010 and January 2011, 12 laryngectomized male patients were involved in our study. In order to survey their general condition, olfactory and gustatory abilities questionnaires were completed by our patients who had previously undergone laryngectomy and also by a control group of 42 persons. The points of the answers given by the patients were summarized; higher total score indicated a more compromised function. For subjective assessment of the olfaction, the Smell Treshold Test (STT) was used. In case of normal olfaction the result of the test was 10 points, lower scores referred to impairment of the olfaction. Three months after teaching the ”polite yawning” maneuver (Nasal Airflow Inducing Maneuver -NAIM) to the patients, control olfactory examinations were carried out. Statistical analysis of the data was run with the use of SSPS 16.0.0 program on a level of significance $p \leq 0.05$ with Student's t-test.

Functional MRI (fMRI) was performed at one laryngectomized patient after applying the maneuver for 3 months.

IV.2 Results

According to the *general health* questionnaire, our patients recieved 43.1 points in average at the initial stage, and the average of the control group was 46.6 points, so we could not prove any significant difference between the two groups. On the *olfaction questionnaire* our patients gained 67.1 points in average, while the score of the control group was 38.8 points: thus at the beginning the patients' olfaction was significantly worse than that of the control population. As for the *gustatory sensation* survey queationnaire no difference was recorded between the scores of the patients and control members. According to the scores of the STT the average of the first measurements in the laryngectomized group was 5.92, which increased to 8.7, i.e. with 47 % after practicing the maneuver for 3 months.

The improved olfaction in one of our patients was demonstrated not only by a subjective test but objectively with fMRI too.

V. Pulmonary rehabilitation

V.1 Materials and Methods

The aim of our study was to examine the effectiveness of the Heat and Moisture Exchanger (HME, *Atos Medical AB, Hörby, Sweden*) used as part of the complete postoperative rehabilitation of 6 patients having undergone total laryngectomy at least 6 months prior to the investigations. The control group comprised 6 laryngectomized patients not wearing HME. Patients were asked to complete questionnaires concerning their *bronchopulmonary and general state* and *ability to speak*. Questionnaires were completed by both groups of patients at the beginning of the examination, then after 6 weeks and finally at the end that is after 3 months. During this period of 3 months, changes in life-quality were also focused on. Patients using the HME system were also to complete questionnaires relating to it.

In order to achieve a thorough assessment of the pulmonary state, besides the questionnaires *pulmonary-function tests* were also carried out in both groups which were repeated after 3 months.

V.2 Results

Based on the analysed responses, the group using the HME showed a slight improvement regarding *general state* as opposed to the control group where minor deterioration could be observed on both the 6-week and 3-months examinations. Values of the responses given to questions concerning *life-quality* on a 1 to 10 scale showed a significant improvement (5.16 vs. 2.83) in the HME group whereas only a minor improvement (6.00 vs. 5.16) could be recorded in the control group. *Bronchopulmonary symptoms* decreased in the HME group on both the 6-week and the 3-months examinations as well. HME helped to decrease the complaints of patients suffering from dyspnoe while the symptoms worsened in the group not using HME. According to the examinations on the 6^{th} and 12^{th} weeks the application of HME significantly reduced the urge to cough, the amount of sputum and in half of the patients it resulted in an increase in physical activity without coughing. In patients of the control group however, a more frequent urge to cough together with an increased sputum production could be observed at the end of the study period. Half of the group also manifested a need to cough on mild physical exertion and also at rest. In half of our patients the use of the HME system also improved speech production. Statistical analyses regarding *pulmonary-function test results* were carried out with a Student's test within the groups. Due to the relatively small number of patients in our study we defined the significance level as $p<0.05$. Examinations after 3 months revealed significantly reduced FVC% (forced vital capacity) and IC% (inspiratory capacity) in the control group, whereas Tiffneau index, IC% and PEF% (peak expiratory flow) showed marked improvement in the group receiving treatment. Changes were more pronounced on individual pulmonary-function tests of COPD (chronic obstructive pulmonary disease) patients. In the autumn period values of the 2 COPD patients not receiving treatment with HME worsened whereas those of the 2 COPD patients treated with HME showed no significant change. It calls attention to the fact that the worsening of the status of patients in the autumn and winter periods could be prevented with the application of HME regarding both symptoms and lung-function parameters.

VI. Summary of novel results

1. In the present study we analysed 15 years of data with the application of voice prosthesis. Such comprehensive work has not been published on this topic in Hungary.
2. Cases where prior to the voice prosthesis implantation previous dilatation was indicated due to a narrowing of the hypopharyngeal-oesophageal junction were analysed separately. According to data in the literature, we were the first to implant voice prosthesis into a jejunum segment following balloon catheter dilatation.
3. This has been the first study in Hungary where a comprehensive questionnaire-survey was employed for the assessment of the effectiveness of the voice prosthesis, the leading method of voice rehabilitation. As a result of the questionnaire-survey we could conclude that the voice rehabilitation achieved by voice prosthesis resulted in sufficient intelligibility in all of our patients in loud environments and on the phone as well. All our patients reported an improvement in life-quality. Consequently, we do recommend the use of the voice prosthesis as a leading method in providing a solution to problems discussed.
4. According to data in the literature, we were the first to introduce the 'polite yawning' technique into the everyday routine of patients who have undergone total laryngectomy as olfactory rehabilitation. The effectiveness of the maneuver was proved by subjective and objective methods alike. Functional MRI was used first for the objective assessment of olfaction of laryngectomized patients on an international level. Our experiences let us recommend the introduction of the 'polite yawning' maneuver into the rehabilitation protocol of laryngectomized patients.
5. Authors were the first in Hungary to examine the effectiveness of the HME. Furthermore, the current study was the first to investigate respiratory functions of laryngectomized patients with whole-body plethysmography. The present study revealed that the use of the HME decreased bronchopulmonary symptoms, improved general state and speech and also improved quality of life. The device is easy to use and is well-tolerable. By these experiences we feel prompted to do all we can to facilitate and encourage the introduction of the HME as an integral part of the general rehabilitation protocol of laryngectomized patients.